Classifications, data and models for European skill needs forecasting

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1. Introduction

Future skill needs in European and other countries have been observed for a long time ([8]). By forecasting the opportunities for work in Europe in a consistent and systematic way, policy-makers, educational institutions and individuals can benchmark the future skill needs in their country of interest against other countries. This is of particular importance since the methodologies and the occupational and educational classifications used by national forecasting institutions in the EU are often different from one another.

EU Member States may review their policies on developing their national education and training systems when the occupational needs are better identified. Use of information on future skill needs may also be important to meet the Lisbon and Stockholm employment rate targets. Active labour-market policies to retrain the unemployed or reintegrate individuals who are economically inactive, may take advantage of the occupational forecasts on employment growth and outflow of workers.

Labour mobility between European countries will probably increase due to fewer legal barriers and better European recognition and certification of diplomas (credentials). Therefore, information on future skill needs in Europe becomes a priority. An example of the potential relevance of international labour mobility to solve bottlenecks on national labour markets is found in a study by Marey et al. (2001). In this study future bottlenecks in the labour markets of EU Member States are identified for research scientists and engineers (RSEs) under different scenarios. The forecasting results indicated considerable shortages of RSEs in various EU Member States. At the same time, for the EU as a whole, there were excess supplies in each of the four fields of study distinguished, no matter which scenario. It was shown that there are opportunities for international labour mobility between particular EU Member States. Since this study demonstrates the advantages of skill needs forecasting when using the same data sources and equal models for many different European countries, the most important results of this study are summarised in Annex 1 at the end of this article.

We propose to analyse the future skill needs of all EU Member States by using similar models and data sources for these countries. The data should be drawn mainly from Eurostat or OECD. Using Eurostat data and European Commission forecasts has several advantages. First, employment growth and changes in employment structure are better comparable across countries when the same sectoral, occupational and educational classifications are used. For example, for the LFS of EU Member States about the same survey methods and definitions are used by the respective national statistical offices. The data provided by national statistical

([8]) See Hughes (1993), Heijke (1994), Heijke and Borghans (1998), Czech National Observatory (1999), Neugart and Schömann (2002).

offices are harmonised by Eurostat. Further, short-term employment forecasts provided by the European Commission or the OECD can be used. By using these forecasts, the occupational and educational forecasts are – as much as possible – consistent with authoritative forecasts, which provide the basis for policy decisions on important social and economic issues in the EU. Other data such as value added and capital that may be required as data input, can also be drawn from Eurostat. For some new Member States the time series are short, other countries may be too small to get reliable data at a disaggregated level.

Annex 2 presents an example of benchmarking analysis on the explanation of the occupational employment structure. We use data from the LFS – harmonised by Eurostat – of EU Member States. The disentangling of the occupational structure changes within countries into industrial, occupational and interaction effects could be a first step to make occupational forecasts for the expansion demand in these countries. To make these occupational forecasts we need both (macroeconomic) sector forecasts and forecasts of changes in the occupational structure within sectors.

In this paper we discuss the goals of European skill needs forecasting (Section 2) and the relevance of benchmarking across countries and time (Section 3), summarise the basic forecasting model (Section 4), and discuss the role of Cedefop in a network of forecasting institutions (Section 5).

2. Goals of European skill needs forecasting

As is argued in, for example, Cörvers et al. (2002), the planning concept has been abandoned in modern labour-market forecasting. Instead, agents on the labour market – for example graduates, employed and unemployed individuals, schools and firms – are continuously trying to improve the match between the skills acquired at school and the skills required on the labour market. Education and training are often not exclusively related to particular jobs. Depending on their educational and training background, individuals can be employed in a broad range of occupations. However, vocational education may generate skills that are only productive within a small occupational domain, suggesting a trade-off between productivity and flexibility of educational courses. Education in health care and teaching strongly raises productivity in the corresponding occupational domains. Schools may want their graduates to have a good starting position on the labour market, in particular within their occupational domain. But in case of a loose labour market within the corresponding occupational domain graduates should be able to work outside their occupational domains. However, outside their occupational domains, they may have a comparative disadvantage relative to graduates with degrees in administration, business or economics. On the demand side of the labour market employers may substitute workers with different educational backgrounds. Substitution possibilities depend on the specificity of skill requirements within firms or organisations, and may change over time due to technological and organisational developments or changes in educational courses.

Instead of a policy of direct intervention to ensure correspondence of the education system to the labour market, providing adequate information would make the labour market more transparent to those choosing a course of study and others investing in education. Transparency would enable the supply of labour to be more responsive to changes on the labour market. It would then automatically conform better to new employment opportunities. Moreover, labour-market

forecasts give employers an indication of the future risk of labour recruitment problems for various skill categories. This enables them to anticipate future shortages and remedy them, for example through internal training and outflow reduction policies for categories of workers for which future shortages are forecast. It follows that increasing transparency for individuals and organisations on the labour market should be the goal of manpower forecasting in EU countries.

Setting this goal of European skill needs forecasting implies that user groups can be identified. Labour-market information is relevant for those choosing a course of study and others investing in education, for employers taking strategic decisions on recruitment and replacement, and for schools offering educational programmes that are both attractive to students and generate the required competences for the labour market. This raises the question to what extent information provided at European level is superior to national labour-market information already available in many countries. The answer is a European labour information system should provide information that is complementary rather than superior to national information. Information provided at European level should in particular be useful for all individuals and organisations interested in looking across national borders (Council of the EU, 2005).

Specifically, European skill needs forecasting could be directed at providing information on:

(a) international opportunities for work after graduation. This enables graduates with a particular educational background to work in any EU Member State;

(b) the competitive position of a particular national educational programme on the European labour market;

(c) international opportunities to work in specialised jobs in EU Member States. This is for those who already have specific labour-market experience in their home country. This could help international labour-market mobility and increase migration flows of workers;

(d) the underutilised human capital potential in EU Member States. This may be useful for firms that want to recruit personnel from abroad or are rethinking the location of their business activities.

3. Benchmarking across countries and time

To ensure greater transparency of employment and training opportunities, it should be possible to benchmark labour-market forecast information from different European countries. Benchmarking may have two dimensions: benchmarking across countries and across time.

3.1. Benchmarking across countries

Benchmarking across countries requires harmonising labour-market information one use of definitions, classifications and models of labour demand and supply. To preserve consistency between aggregated labour-market information (e.g. employment growth of sectors) and detailed information (e.g. employment growth of particular occupational groups), it is important to use both a fitting general forecasting model and national databases which distinguish between the various occupational groups and fields of education. In a top-down approach to labour-market forecasting we can adequately deal with interactions between different labour-market segments and substitution processes between occupational groups ([9]).

([9]) See the top-down approach to labour market forecasting in the Netherlands as discussed by Cörvers (2003).

A top-down approach – from a European perspective – can also better take account of mobility flows between countries.

Top-down forecasts and scenarios should exploit international comparable databases. These data sources should cover all segments of the labour market, be consistent with data on other important national economic developments, for example GDP (gross domestic product) growth, employment growth, demographic trends, and be consistently differentiated to lower levels of aggregation. These data sources should be available EU-wide on a regular and coherent basis. If available databases do not fulfil all necessary conditions for international comparative analyses the network should see these conditions are met. Forecasts and scenarios should be based on international consistent forecasts of economic, social, and demographic variables at macro level.

A top-down approach implies that one should not concentrate solely on occupations related to vocational education and training. The strength of such modelling is that the developments on the whole range of occupations on the labour market are considered, including intermediate occupations. A model of the labour market that just focuses on the intermediate occupations cannot account for shifts in the occupational structure within sectors of industry. For example, if professional occupations mainly benefit from a strong increase in employment growth at macroeconomic level, the employment growth of intermediate occupations may be overestimated if we shifts in occupational shares within sectors are not considered.

4. Benchmarking across time

Forecasting skill needs often refers to anticipating changes in employment levels, or changes in the labour-market position for particular fields of education. This implies that information should be provided on both actual and future labour-market opportunities. For example, although it may be attractive for graduates in economics to migrate to country A with high wages and low unemployment and overschooling (underutilisation) in economics relative to country B, a bad labour perspective in economics for country A may change their decision since wages may go down and unemployment and (overschooling) underutilisation rise over time. Graduates could consider this information when looking at the costs, benefits and risks of migration to a particular country.

Information on the expected future labour-market situation may concern the following variables (see Section 4 for further explanation):

(a) expansion demand by sector, occupation and education,
(b) replacement demand by occupation and education,
(c) number of job openings,
(d) supply by education,
(e) indicator of the future labour-market situation for graduates,
(f) indicator of the future recruitment problems for employers.

The information provided may be limited to a qualitative description of labour-market prospects of training categories or recruitment problems of particular occupations, on a scale from 'good' to 'poor'. Use of qualitative descriptions would prevent quantitative forecasts being treated as more precise than they are.

To benchmark expectations on the future labour-market situation, information should be provided on the current labour-market situation for all sectors, occupations and educational fields distinguished in the forecasting model. The information may concern the following variables:

(a) unemployment and participation per educational level and field,
(b) wage level by occupation and education,
(c) working below level (underutilisation or overschooling) or outside occupational domain,
(d) distribution of occupational employment per educational category,
(e) educational employment structure within occupations,
(f) working part-time (involuntary) or in short-term contracts,
(g) other conditions of employment,
(h) volatility of employment by occupation and education,
(i) vacancy rates by occupation and education,
(j) migration flows by education.

A bad indication for the future labour-market situation for a particular type of education may not only lead to an increase in unemployment or a lower wage level, but also to more underutilisation or working outside an occupational domain, worsening conditions of employment, and decreasing immigrants with the educational background in question, etc. (see also Wieling and Borghans, 2001).

Forecasts could be limited to the medium term, a period of five years. Within this horizon changes on the labour market are less uncertain than in the long term, in particular the outflow of graduates from the educational system to the labour market. Moreover, uncertain results of substitution, geographical mobility and other adjustment processes can be decisive, in particular when discrepancies between demand and supply are extremely large. A forecast period of five years is sufficiently long to produce useful labour-market information for those investing in a course which will last for several years. However short-term forecasts for the coming year or two-year period may be important for recruiting personnel, for short-term training courses and other short-term labour-market programmes and for preparing the unemployed or non-active to enter the workforce.

Forecasts do not have to be repeated every year. This makes it possible to keep a finger on the pulse, while leaving sufficient time to evaluate observed differences between forecasts and the achieved results on the market and to use these evaluations to improve the forecasting method. Differences between forecasts and results tend to increase over time. Waiting longer than two or three years to make modifications will not only encourage bad decisions on training and education, but visible mistakes in forecasting will also contribute to a negative image of labour-market forecasts.

5. Forecasting labour demand and supply

On the demand side of the labour market a distinction should be made between demand resulting from future changes in employment levels – expansion demand – and demand due to retirement and occupational mobility – replacement demand. The model can be based on the methodologies used by, for example, IER for the UK, ESRI for Ireland and ROA for the

Netherlands (see Heijke, 1994; Heijke and Borghans, 1998; Neugart and Schömann, 2002). These methodologies have already been adopted by some other countries.

Forecasts of expansion demand can be based on short-term employment level forecasts from the European Commission. It is necessary to differentiate these forecasts of employment growth by sectors of industry, and to lengthen the forecasting period. Employment trends from the past can be used to extrapolate sectoral employment growth in different scenarios (e.g. high versus low growth). In place of fixed coefficients for the occupational and training structure of employment, explanatory models are used to describe the changes in both structures over time. Additional explanatory variables such as value added, labour productivity and investments in R&D and capital could be used. Likewise, expansion demand per educational category should be forecast, accounting for changes in educational structures within occupations, including increasing skills requirements (upgrading).

Labour-market demand consists not only of expansion but also of replacement demand, which arises when workers retire, leave the labour force under an early retirement scheme or because of a disability, withdraw from the labour-market temporarily, or switch to another occupation, complete an educational course at a higher level or in another direction, etc. Because there is no appropriate data for mobility flows on the labour market, stock data can be used. By means of the so-called cohort components method cohort-change rates can be used. These are based on the number of persons of the same birth cohort employed at two different times. The resulting inflow and outflow can be translated into replacement demand by occupational group or type of education. Another important step is to project the historically measured net replacement demand rates per age-sex group for a particular occupational group or type of education onto the age-sex structure of the workers at the beginning of the forecasting period (see for further details e.g. Cörvers et al., 2002).

Replacement demand only arises if departure of an employee leads to a vacancy for a new entrant. If departure of a worker is taken as an opportunity to cut employment levels, no replacement demand results. These flows out of the labour market are irrelevant for newcomers. If employment levels rise, expansion demand and replacement demand together compose the job openings for newcomers to the labour market. If they fall, job openings can only arise because of replacement demand.

To be able to show future labour-market prospects for newcomers to the labour market, we have to compare job openings for newcomers with the expected supply of newcomers. The latter consists of the future flow of school-leavers entering the labour market and the outflow from post-initial training courses during the forecast period, plus the supply of short-term unemployed persons waiting to enter the market at the start of this period. It is assumed the long-term unemployed, who have been looking for work for longer than a year, no longer constitute serious competition for school-leavers.

An indication of future labour-market prospects for newcomers to the labour market is calculated, for each type of education, by comparing the expected flows of demand and supply with each other. This indicator shows any expected discrepancy between demand and supply for each type of education. Excess supply does not necessarily imply the group in question will automatically become unemployed, or a supply shortfall automatically leads to unfilled vacancies. In practice, school-leavers with a type of education for which supply exceeds demand suffer from a worsening position. They are more likely to have to accept work below their level, get less favourable contracts, be paid less and more likely to work part-time involuntarily (Wieling and Borghans, 2001). In such situations, employers normally adjust their demands

and recruit people with a higher educational background. However, if there is a supply shortage, school-leavers will not have to accept a job at a lower level, for lower wages, etc.

Because of substitution processes, there are fewer job openings for those suffering from 'crowding-out' with types of education in excess supply. However, for those with educational backgrounds closely related to types of education in short supply, there will be extra job openings. These passive substitution effects are thus important determinants of labour-market prospects for types of education.

For European skill needs forecasting it is important to cast light on the possible adjustment and substitution processes between countries. These processes may take place on both the supply and the demand side of the labour market. On the supply side of the labour market, workers or graduates may choose to migrate to another country when the labour-market situation in their country is bad. Young people may also choose to continue their studies in another country. Although the flows of workers, graduates or students may only be marginal as a percentage of the total labour force, for some occupations (e.g. drivers or construction workers) these numbers may be substantial. On the demand side of the labour market, firms may decide to relocate their businesses to other countries because of the availability of more or better skilled workers, at lower wage costs. Information on the actual and future opportunities to move between countries may improve the matching of labour-market needs (Council of the EU, 2005).

6. Role of Cedefop

There must be a balanced role for both Cedefop and researchers in the forecast activities of the network. Cedefop can play an important role in initiating and supporting network activities and disseminating the outcomes to the public. It can bring all parties involved together and organise meetings. Cedefop can also play a role in finding financial support for network activities. Network participants must be given enough autonomy to participate fully in their own networks, choosing the criteria for selecting participants, develop plans for research activities and disseminate outcomes, draw up strategies to realise these plans and set priorities. A committee of two or three leading participants and a member of Cedefop could be set up to drive things forward.

It is important to have a clear picture of the role of the different parties interested in network activities and to organise the network accordingly. The network should primarily consist of highly qualified independent researchers. Other parties should only participate when specific contributions are needed - preferably researchers who already take part in similar analyses in other frameworks. Every participating researcher has to play an active role and free riders have to be excluded. Representatives of governments, VET systems and associations of employees or employers should only take part in network activities when their responses to plans and study results or dissemination of results are on the agenda. Separating meetings where researchers freely speak about their plans and work from meetings where policy-oriented people can comment on plans, study results and disseminating results will make the network more effective and stimulating.

Annex 1: The labour market for research scientists and engineers (RSEs) in Europe – example

In a knowledge-driven global economy, it is essential that the education system produces sufficient science and technology (S&T) graduates both in quantitative and qualitative terms. The hard core of personnel in R&D departments are RSEs. In many European countries there is serious concern about a future shortfall in supply, compared to demand, for RSEs, i.e. researchers in the exact sciences: mathematics and natural sciences, technical sciences, agricultural science and medical science. Among the causes of the possible shortage of RSEs, demographic developments such as the ageing working population should be mentioned first. Rapid development in various technological fields, as a result of which researchers' knowledge becomes obsolete, also plays an important role in the demand for freshmen. Finally, many European countries face declining interest of youngsters in science and engineering studies.

Forecasts for the various Member States indicate that several Member States will face shortages of RSEs in one or more fields of study. These forecasts should (at the time of producing them), however, be interpreted as *ex ante* forecasts. In practice, labour markets have adjustment processes which will bring the difference between labour demand and supply down. This does not mean that there will be no *ex post* shortages. It also does not mean that *ex ante* shortages matter less: adjustment processes often require high costs. Adjustment processes may take place within the labour market for RSEs in a specific field of study, between labour markets for RSEs with different fields of study and between labour markets for RSEs in different countries.

Adjustment processes

An important adjustment process on the demand side of the labour market for RSEs with a specific field of study is the time spent by RSEs on non-R&D tasks. Workers with other qualifications (lower level of education or other field of study) can be recruited to perform the non-R&D tasks. When the *ex ante* shortage of RSEs is not too large, this adjustment process may reduce the number of job openings in the *ex post* situation to match the low level of RSE inflow. A closely related adjustment process is an increase in total working hours, by stimulating overtime of qualified RSEs. Other adjustment strategies that employers may follow to reduce shortages include improved management, substituting physical capital for human capital and even reducing R&D activities (see Borghans et al., 1998; Wieling and Borghans, 2001).

Adjustment processes may also take place on the supply side of the labour market for RSEs with a specific field of study. When the ratio of RSE inflow to total flow of S&T graduates is relatively small, there may be a hidden potential of S&T graduates who do not yet apply for RSE jobs *ex ante*, but who may decide to do so *ex post*. Motives may be good employment opportunities for RSEs or changing job preferences induced by for example promotional campaigns. Of course, higher wages may also be used to attract more RSEs. However, one might wonder if the productivity of these workers in RSE jobs is at the same level as the productivity of S&T graduates with a higher preference for RSE jobs. An additional pool of S&T graduates from which new RSEs may be recruited are the unemployed. Since supply forecasts refer to the total flow of S&T graduates from 1997 to 2002, the relevant figure is the number of unemployed S&T graduates in 1997. However, according to the labour queue theory (Thurow, 1975), a longer duration of unemployment, on average implies lower quality of the unemployed S&T graduate. In addition, there may be a loss of skills. Hence both supply side adjustments may be accompanied by a loss in quality and productivity.

An additional adjustment process may take place between labour markets for RSEs with different fields of study. An important opportunity is the similarity between certain natural science curricula and technology and engineering curricula. For example, a shortage of chemistry RSEs (natural scientists) may be alleviated by an excess of chemical engineering RSEs (technology and engineering). From the demand side this would probably entail reorganisation of R&D tasks of natural scientists and on the supply side it implies that graduates are willing to work outside their field of study.

Another possible adjustment process is international labour mobility. A shortage of natural scientists in one Member State may be reduced by an excess of natural scientists from another. Of course, this requires a fully integrated European labour market with a geographically mobile labour force. However, in practice there are often various barriers to mobility such as mutual recognition of educational qualifications, geographical distance, differences in language and culture and fiscal differences. On the other hand, in-company mobility may promote international mobility. Incentives for international migration are differences in wages and benefits. After full introduction of the euro the lack of transparency of the real wage differentials will decrease, which will probably further ease international mobility.

In many instances, international labour mobility may be a considerably less costly adjustment mechanism than intra-national adjustment mechanisms. According to human capital theory (Becker, 1962), it is an adjustment mechanism especially suited for young S&T graduates. Young people have a longer period to write off the costs of moving to another country, while S&T graduates have a large knowledge potential which can generate a high income path (Hansen et al., 1992). Also, international mobility within a multinational firm often relates to higher educated staff.

It is however important to recognise there are costs both for the demand side and the supply side of the labour market associated with all these adjustment processes. If an ex ante shortage does not materialise as an (equally large) ex post shortage due to the adjustment processes described above, this does not mean that manpower problems are overestimated by the *ex ante* shortage. The reduction from the *ex ante* shortage to the *ex post* shortage has come at a cost, which in some cases can be considerable. So the *ex ante* shortage provides a general indication of the problems associated with a lack of balance between labour demand and supply.

To assess possible future shortages of RSEs in various EU Member States, we developed a model to track the relevant flows of RSEs on the labour markets. The estimated models are from national models used by ROA, but the concepts of expansion and replacement demand, and the inflow of graduates on the labour market are the same as described in Section 4. Under this approach forecasts are made of the flows entering and leaving the labour market in the period from 1997 to 2002. This approach enables us to make a confrontation between labour demand (the expected job openings for RSEs) and labour supply (expected inflow of new RSEs).

Results

Table 1 summarises the results of the study by Marey et al. (2001). The table provides an overview of expected RSE shortages in various Member States at the end of the forecasting period in 2002 (second column), the effectiveness of intra-national adjustment processes (third column) and the suggested international RSE flows which could solve the most serious shortages (fourth column).

Table 1: Overview of expected RSE shortages in 2002 and effectiveness of adjustment processes

Country	Projected RSE shortages (1997-2002)	Effectiveness of domestic adjustment processes	Possible sources of RSE inflow from other Member States
Belgium	None		
Denmark	Natural sciences	limited	Greece, Spain, Italy
Germany	Natural sciences medical sciences	limited sufficient	Greece, Spain, Italy
Greece	None		
Spain	None		
France	Natural sciences	sufficient	
Ireland	Medical sciences	limited	United Kingdom
Italy	Medical sciences	sufficient	
Netherlands	Natural sciences medical sciences	limited limited	Greece, Spain, Italy, France
Austria	Natural sciences medical sciences	sufficient limited	France
Portugal	Natural sciences	sufficient	
Finland	None		
Sweden	Natural sciences technology and engineering medical sciences agricultural sciences	Sufficient sufficient sufficient sufficient	
United Kingdom	None		

It follows that not all countries may be able to deal with RSE manpower problems themselves, specifically Denmark, Germany, Ireland, the Netherlands and Austria. This means there are opportunities for international labour mobility, since no shortages were expected for the EU as a whole. The forecasts, therefore, emphasise the importance of European labour-market integration. The shortages of medical science RSEs in Ireland are relatively small compared with the excess supply of medical science RSEs in the UK in all scenarios, except the high GDP growth – high human capital growth – scenario. Given the short distance, cultural similarity and absence of language problems between Ireland and the UK, the mobility of medical science RSEs from the latter country to the former would solve the shortages in Ireland. The shortages of medical science RSEs in Austria and the Netherlands can also be solved by mobility from countries with excess supplies, especially France. The shortage of natural science RSEs in Germany are considerable, but countries like Greece, Spain and Italy have considerable excess supplies of graduates with the required educational backgrounds which could fill the job openings. These countries could also contribute to solving the shortages for natural science RSEs in Denmark and the Netherlands.

Of course, international labour mobility is not only important where certain Member States are unable to solve their own RSE manpower problems. It may also be a cheaper alternative to costly intra-national adjustment processes in a Member State facing shortages of RSEs. For example, while Sweden is expected to face mild shortages in all fields of study distinguished, Finland has excess supplies in all fields. Since Sweden and Finland are neighbouring countries and many Finnish people have a good grasp of the Swedish language, the mobility of Finnish RSEs to Sweden would be an answer to the shortages in Sweden, without the costs associated with intra-national adjustment processes.

Annex 2: Shift-share analyses for countries in the EU – example

This annex presents the results of a shift-share analysis of the occupational structure of two countries, Estonia and the Netherlands, relative to the average of 25 EU countries. The analysis could be a first step to making occupational forecasts for expansion demand in these countries. The analyses based on the LFS of EU countries could also answer the following questions.

(a) Are the dynamic changes in countries' occupational structure different across new and old Member States?

(b) Are new Member States converging towards the structure of old Member States?

(c) What is the most important effect of counting the dynamic changes in occupational structure? Is this result sensitive to the group of countries in terms of old and new Members States?

Changes in a country's occupational structure over time can be attributed to three effects: the industrial effect (I_i^k), the occupational effect (II_i^k) and the interaction effect (III_i^k).

$$dd_i^k = o_i^k - \bar{o}_i = I_i^k + II_i^k + III_i^k$$

Where the changes in every occupation i is noted as dd_i^k; o_i^k denotes the country's I^{th} occupational share in country k and $\bar{o}_i$ the EU cross-country average occupational share. $\bar{o}_i$ has been calculated as follows:

$$\bar{o}_i = \frac{\sum_{k=1}^{n} o_i^k}{n}, k = 1, \ldots, n$$

The number of countries, k, in the analysis is 25, $k = 1, \ldots, 25$. Occupational shares are at one-dimensional ISCO classification level, $i = 1, \ldots, 11$, one additional classification group was added to account for the share of the unknown occupation group. Industry shares are at one-dimensional NACE classification level, $i = 1, \ldots, 18$, where one sector includes an unknown economic activity.

The occupational shares across countries and for the EU average sum up to one:

$$\sum_i o_i^k = 1, \text{ for every country } k \text{ and } \sum_i \bar{o}_i = 1$$

The occupational shares for every industry and employment shares for every country sum up to one:

$$\sum_i o_{ij}^k = 1, \text{ for every industry } j \text{ and country } k; \sum_i \bar{o}_{ij} = 1 \text{ for every industry } j$$

$$\sum_j s_j^k = 1, \text{ for every country } k \text{ and } \sum_j \bar{s}_j = 1$$

The industrial effect (I_i^k) reflects the country's occupational structure due to the employment allocation between production sectors. If the country's occupational structure for every economic activity were equal to the EU average, then differences in country's and EU overall occupational structure would be wholly accounted for by the differences between the country and the EU with respect to the employment allocation between production sectors. Or in other

words, if the technology for a production sector were the same for every country in the EU, the occupational structure of the individual country could still differ because of the different importance of each production sector.

$$I_i^k = \sum_j \bar{o}_{ij} * \left(s_j^k - \bar{s}_j\right)$$

Where $\bar{o}_{ij}$ notes the EU average I^{th} occupational share in industry j; s_j^k the country k industry j employment share and $\bar{s}_j$ the EU average industry j employment share.

The occupational effect (II_i^k) gives rise to differences in the occupational structure within similar production sectors across countries. If the country's industry structure in terms of employment were the same as the EU average, its overall occupation structure could differ because of the different occupational structure across similar production sectors. Thus this component may reflect the differences in occupational structure due to different technologies used in the same production sector.

$$II_i^k = \sum_j \left(o_{ij}^k - \bar{o}_{ij}\right) * \bar{s}_j$$

Where o_{ij}^k notes the country k's I^{th} occupational share in industry j, $\bar{o}_{ij}$ the EU average I^{th} occupational share in industry j and $\bar{s}_j$ the EU average employment share in industry j.

The interaction effect (III_i^k) arises due to interaction between occupation i shares across industries and employment shares across industries, that calculated for every occupation i and every country k. Interaction effect is positive if compared to EU average country's occupation i is more important for sectors that country is specialised in. The opposite holds if I 's occupation is unimportant for sectors that country is specialised in.

$$III_i^k = \sum_j \left(o_{ij}^k - \bar{o}_{ij}\right) * \left(s_j^k - \bar{s}_j\right)$$

Where again o_{ij}^k notes the country k's I^{th} occupational share in industry j; $\bar{o}_{ij}$ the EU average I^{th} occupational share in industry j; s_j^k the country k employment share in industry j and the EU average employment share in industry j.

Estonia

Results of the static analysis for Estonia are shown in Table 2. Compared to EU average Estonia has much more workers occupied in lower skills occupational groups; the only exception is the first occupational group of legislators, senior officials and managers. The industry mix component accounts for the differences in occupational structure due to differences in allocation of employment across industries. If the production technology in Estonia were the same as the EU average, Estonia would still have more workers employed in lower occupational levels. Thus, the Estonian industry structure uses lower level occupational labour, in sectors such as fishery; mining; manufacturing; electricity, gas and water supply which, compared to EU-25 average, are more important in the Estonian economy. The occupational structure differential component accounts for the differences in occupational structure due to differences in technology across production sectors. If Estonia had the same employment structure of economic activities then due to different technologies in production sectors it would still have more workers occupied in lower level occupational groups. Thus in sum, both the industry structure and production technology in Estonia are inclined towards lower skilled labour.

Table 2: Estonian occupational structure compared to EU-25 average, 2004

Occupational group	total effect	industrial	occupational	interaction
Legislators, senior officials and managers	0.04551331	-0.002240	0.045001	0.002755
Professionals	-0.02325733	-0.003660	-0.018990	-0.000610
Technicians and associate professionals	-0.01804349	-0.007120	-0.005770	-0.005150
Clerks	-0.05952775	0.000101	-0.060280	0.000656
Service workers and shop and market sales workers	-0.00434834	-0.017890	0.017060	-0.003520
Skilled agricultural and fishery workers	-0.02215647	-0.005380	-0.019410	0.002634
Craft and related trades workers	0.00531644	0.016762	-0.009910	-0.001540
Plant and machine operators and assemblers	0.05434135	0.023846	0.024610	0.005885
Elementary occupations	0.02557069	-0.003500	0.025137	0.003932
Armed forces	-0.00105355	-0.000110	-0.001040	0.000100
Occupational group unknown	-0.00235484	-0.000800	-0.002350	0.000805

Source: LFS, own calculation.

The Netherlands

Results of the static analysis for the Netherlands are shown in Table 3. The differences in occupational structure compared to EU-25 average are quite the opposite of the Estonian example – there are more workers employed in higher occupational groups and fewer workers in lower occupational groups. The industry mix component indicates that if the technology were equal to EU-25 average the differences in industry structure would still make more workers work in higher occupational groups. This shows the industry structure in the Netherlands is more inclined to industries that use more high-skilled workers. The occupational structure differential component shows that if the Dutch industry structure were the same as EU-25 average it would still use more high-skilled workers as its production technology originates more from high-skilled labour input. Thus, in contrast to the Estonian example, the Dutch economy relies more on workers from higher occupational groups, both in terms of industry structure and production technology.

Table 3: The Netherlands' occupational structure compared to EU-25 average, 2004

Occupational group	total effect	industrial	occupational	interaction
Legislators, senior officials and managers	0.017899	0.002306	0.030248	-0.014660
Professionals	0.049034	0.016777	0.031783	0.000474
Technicians and associate professionals	0.033722	0.020121	0.005731	0.007869
Clerks	0.019359	0.005155	0.017535	-0.003330
Service workers and shop and market sales workers	-0.000950	0.012529	-0.012250	-0.001240
Skilled agricultural and fishery workers	-0.027970	-0.019970	-0.017930	0.009931
Craft and related trades workers	-0.053090	-0.030050	-0.031580	0.008543
Plant and machine operators and assemblers	-0.033410	-0.017050	-0.019530	0.003170
Elementary occupations	-0.010130	-0.003340	-0.009720	0.002934
Armed forces	-0.001550	0.001094	-0.001410	-0.001240
Occupational group unknown	0.007086	0.012429	0.007120	-0.012460

Source: LFS, own calculation.

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